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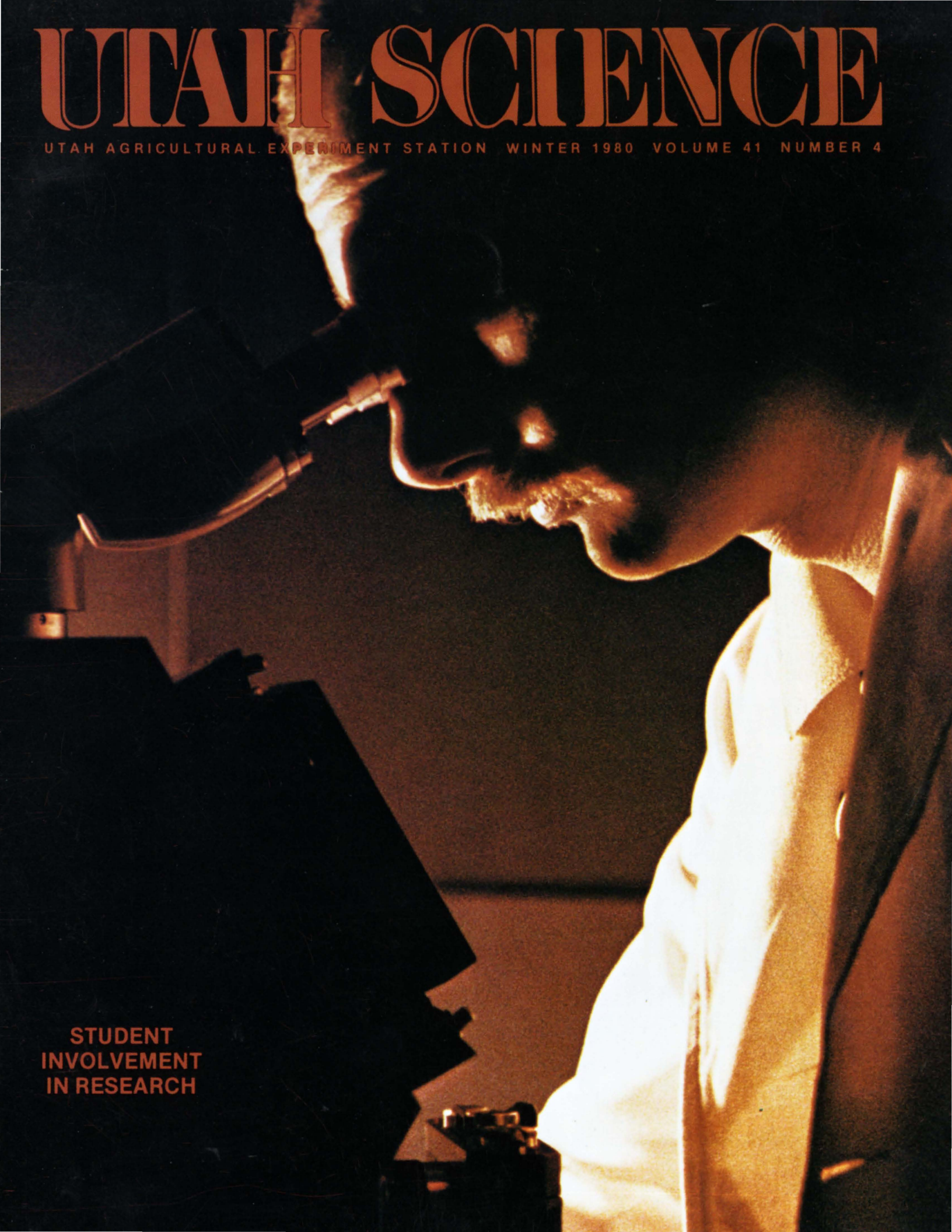


STUDENT INVOLVEMENT IN RESEARCH

WINTER 1980 VOLUME 41 NUMBER 4

UTAH SCIENCE

UTAH AGRICULTURAL EXPERIMENT STATION

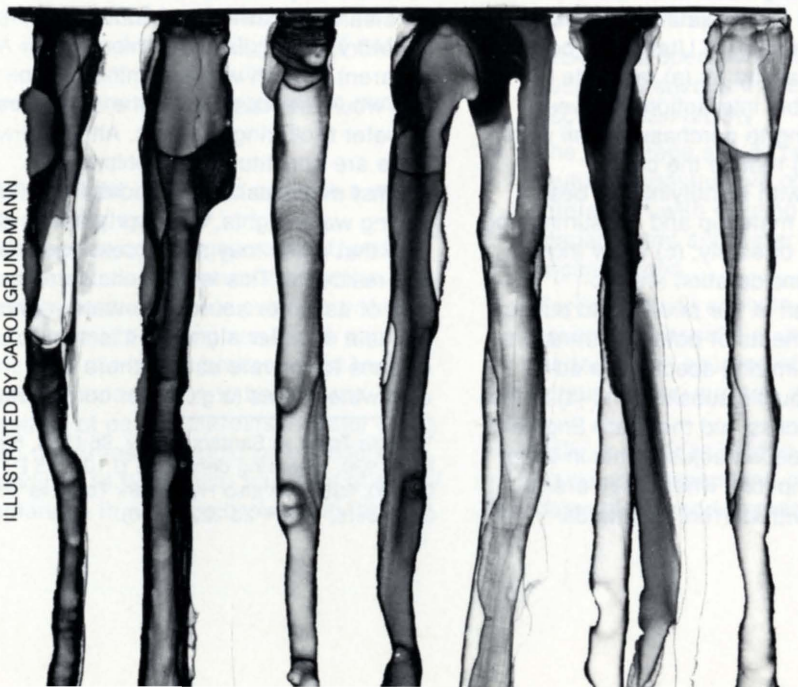
ABOUT THE COVER — COVER PHOTO BY CAROL GRUNDMANN

Students such as Scott Clark learn scientific techniques and problem-solving thought processes while earning their doctoral degrees. As they recognize and develop their individual potentials as scientists, their research contributes to our need for expanded knowledge.

JAY M. BAGLEY,
KIRK R. KIMBALL,
and LEE KAPALOSKI

WATER RIGHTS

CAN THEY BE BROKERED?



ILLUSTRATED BY CAROL GRUNDMANN

AS ECONOMIC ACTIVITY IN UTAH CHANGES in kind, location, and level, increasingly active markets for water will result. Urbanization and industrial processes will foster new water use patterns. In areas where the available water supply is already fully appropriated, these changing demands can be satisfied only through transfers, shifts, or exchanges in resource ownership. Facilitating water rights transfers, especially those involving users unfamiliar with the complexities of transferring water equities, will be an important need.

In general, the market is the process by which ownership transfers take place. For the market to operate effectively, sellers need to know the prices that are being offered for water rights. Buyers need to know what it will cost to acquire and adapt a given supply to another use of interest. As the number of water rights holders and the diversity of uses increase, the informational base and communication mechanisms (which allow both buyers and sellers to achieve most cost-effective matchups) will have to expand. The real estate business responded to expanded activity by spawning numerous real estate brokering services using a variety of advertising media. Some of the marketing and information transfer concepts developed might be advantageously incorporated in a brokerage service that specialized in the transfer of water rights.

Where We Are

At the present time, a prospective buyer of a water right must canvas possible sources of supply and initiate negotiations to procure a satisfactory supply. In some instances, private legal and/or engineering advice is sought to provide assurances that a water rights transaction is physically and economically sound and legally correct. However, such aid is usually without the complete informational base needed to expose the full array of alternate supply options and to systematically select the one best suited for the expressed need.

Because the State Engineer has administrative control over all waters of the state, and must approve water rights transfers, it is often presumed that the Office of the State Engineer provides a brokering service of sorts. In reality, the State Engineer's role in most water transactions is that of a "referee" rather than an "arranger" such as a broker of real estate. As a quasi-judicial officer, the State Engineer does not participate directly in the water marketing process involving negotiations between buyers and sellers. Neither is the State Engineer viewed as an informational storehouse about who is willing to sell water rights and who wants to buy.

In summary, Utah is experiencing a growing number of water rights transactions. Statistics from the Office of the State Engineer indicate a steady increase in the number of applications processed to appropriate, change use, and exchange water rights. Obviously, water users are finding new uses that require new supplies and are transferring supplies from current uses presumably to higher valued uses through a market process. Many of these exchanges may involve complex rearrangements in ownership, joint use of management facilities, and the derivation of equitable mitigating or compensating features. It seems, therefore, that now is the time to consider all possibilities for reducing potential impediments to the water transfer process. A water rights brokering service might be a useful device for assembling information about water availability and need, and making such information readily available in a centralized location. Such a service might further enhance its usefulness by providing professional capability to appraise alternative matchups of source and supply and evaluate the hydrologic impacts of any given water rights transfer.

Can we justify such a service?

Justification for activating a water rights brokering function in Utah must be found in its ability to: (a) facilitate knowledgeable interactions between those desiring to purchase or sell water interests; (b) reduce the costs associated with identifying the best buyer-seller matchup and consummating the transfer of equity; (c) allow more objective consideration and accommodation of the private and public interest elements of potential transfers, thereby minimizing speculative advantage or public subsidy; and (d) in the transfer process, aid the State Engineer in making needed adjustments in water rights descriptions where they are incongruent with current standards.

The benefits of a water brokering operation would accrue primarily to the immediate parties to a water rights transfer. Because transfers are generally in the direction of higher valued uses, the public should derive some indirect benefit. Sellers would benefit as the brokerage identified more "bidders" so that the best possible price could be secured, and by obtaining a greater return from the sale than would be realized if the water were kept in its present productive use. The buyer of a water right would profit from being able to choose the least costly supply alternative from a number of supply potentials.

By appropriate coordination, a brokering system could keep the Office of the State Engineer continuously updated regarding shifts in the water market. With knowledge of current and prospective water market activity, the State Engineer (and Utah in general) would have some forewarning about possible problem-generating trends. The brokering service could alert parties considering a water transaction to conditions that must be met if the transfer is to be acceptable to the State Engineer. Such early warning could minimize painful and (perhaps) costly adjustments which could unsettle arrangements otherwise carried to an advanced and relatively inflexible stage.

Possible impediments

No clearly discernible constitutional, statutory, or regulative elements are apparent in Utah water administration that would seriously stifle the operation of water brokering systems. Although there are constitutional prohibitions against municipal corporations transferring water rights, the courts have held that cities may sell excess water to non-residents. This is not considered a sale of its water sources or water rights but sale of water alone as it is sold to citizens for private use.[1] Others that own water rights (e.g., water companies,

[1]Genola Town vs Santaquin City, 96 U.88, 80 P. 2d 930, rehearing denied 96 U.104, 85 P. 2d 790, 935. See also Hyde Park Town vs Chambers, 104 P. 2d 222 (1940).

metropolitan water districts) are not constitutionally prohibited from making water rights transfers. There are statutes and rules, however, that may limit the geographic area that an organization might serve and its freedom to transfer, exchange, or otherwise manage its water rights. Procedural requirements that govern the voluntary transfer of water rights are mostly aimed at protecting vested rights that draw supplies from the same system in which a change in use is being contemplated. Although municipalities and water conservancy districts are not able to dispose of water rights to parties outside their jurisdiction, they now commonly contract with outside users for delivery of water and participate in the lease or rental market with supplies for which they have no immediate use while awaiting increased demands from expected growth.

Nevertheless, institutional peculiarities and encumbrances may influence the ease of transferring water. Debt status and contractual commitments may constrain the market potential of particular water equities. Likewise, cultural and psychological biases may distort value perceptions and thereby affect the willingness of some water management entities to buy or sell water.

The operation of factors outlined above is not unique to water markets. Real estate markets and other markets are influenced by similar sets of factors. A water brokering system would need to recognize these institutional peculiarities and be prepared to deal with them.

Who might qualify to operate a water brokering system?

The operational, organizational, and administrative framework would be pivotal in the ultimate success or failure of a water brokering service. A primary activity of a water broker would be to provide information to buyers and sellers of equity interests in water rights so that transfers could be expedited. In addition to facilitating transfers of equity interests in water, a broker may help clients work out "packages" of water rights that provide optimum solutions to specific supply problems.

A brokering organization having professional capabilities required to analyze and evaluate the physical and legal consequences of a change in water use would have definite advantages over a brokerage offering only a buyer-seller listing service. Desirable attributes or operating criteria of a water brokering organization might be:

1. Utilization of services should be voluntary.
2. Operating policies and procedures should be consistent and compatible with existing statutes governing the transfer and change in use of water.
3. Functions and authorities should be compatible with, and complementary to, those of relevant state agencies.
4. The operation of the brokerage should result in a net positive social benefit (benefits greater than costs of providing service).
5. The brokerage should be free from any encumbrances or commitments that could compromise objectivity in assisting clientele.
6. The brokerage should have no responsibility or authority for formulating state water policy (procedural emphasis).
7. Brokerage operations must be subject to adequate public and fiscal accountability.
8. The brokerage should perfect a mutually constructive operating interaction with existing water management and water service organizations.
9. Service should apply to all kinds of recognized beneficial uses and pertain to all sources of supply (groundwater, surface, etc.).

Ideally, a water brokering organization should be an independent, objective facilitator of the market process. It should have no vested interest to protect and not be a participant in market activities related to the water supply or its distribution to end users.

Many kinds of private and public organizations could administer a water brokering service. A cursory evaluation of 16 existing water management agencies and organizations shows that some already perform limited water brokering functions generally within the framework of their own corporate entitlements. In terms of the preceding operating criterion, however, only a few possess all the desired characteristics at the present time.

Of the array of water organizations and institutions operating in Utah which might operate a water brokering system on an integrated statewide basis, the Office of the State Engineer (public) and the Utah Water Users Association (private) appear to best meet the desired characteristics for providing the service. Of course, any organization so inclined could undertake such a service within whatever jurisdiction is chose to operate, much as real estate operations function at present.

ABOUT THE AUTHORS

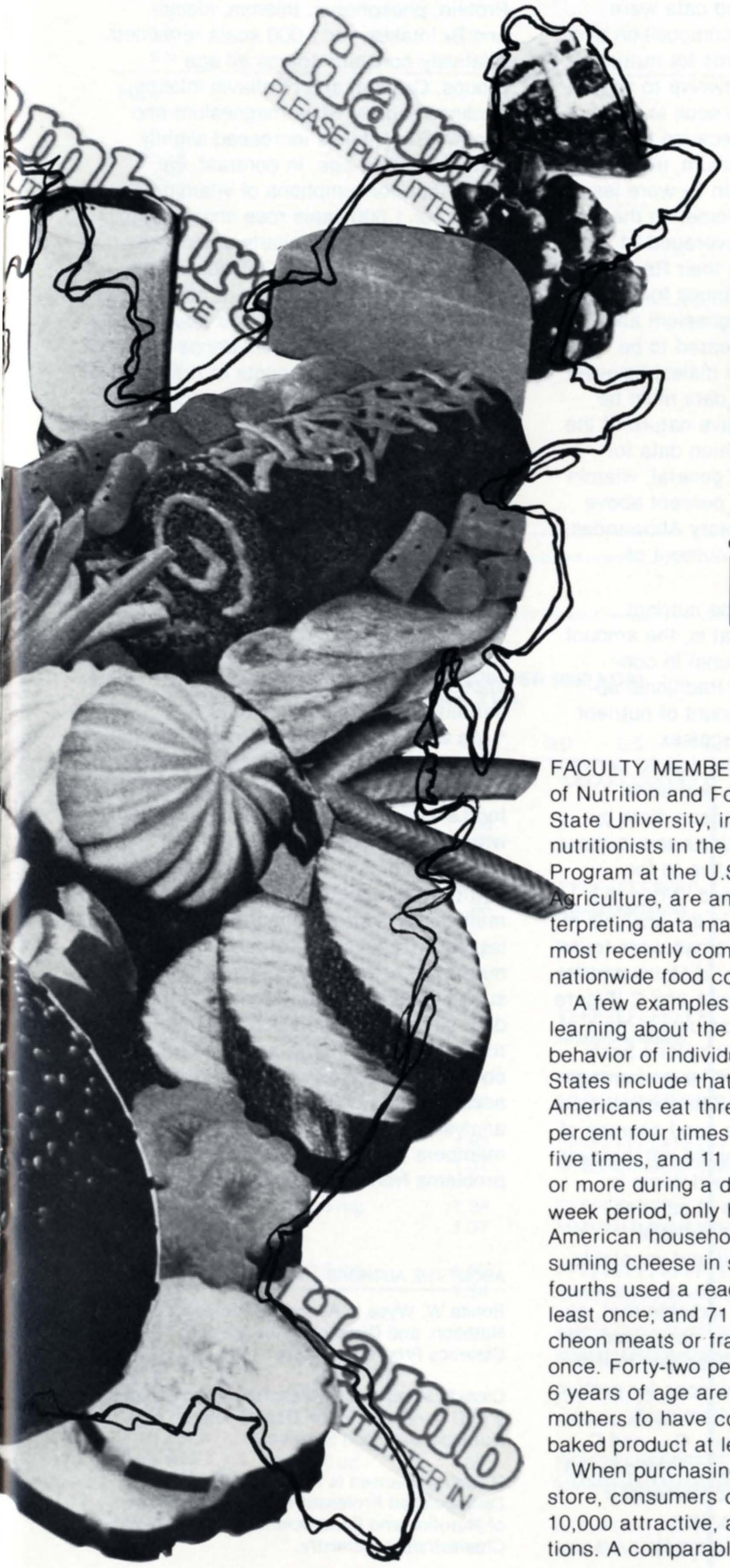
Jay M. Bagley is a Professor of Civil and Environmental Engineering at USU. His research experience has included substantial involvement in the legal, institutional, and policy elements of water resources management.

Kirk R. Kimball is a resource policy analyst with the Utah Water Research Laboratory specializing in institutional economics and public administration.

Lee Kapaloski is a practicing attorney specializing in legal and policy problems related to local and regional resource planning and development.

ILLUSTRATED BY CAROL GRUNDMANN

BONITA W. WYSE, CAROL T. WINDHAM, and R. GAURTH HANSEN



Food & Nutrition Patterns in the U.S.

FACULTY MEMBERS in the Department of Nutrition and Food Sciences at Utah State University, in collaboration with nutritionists in the Human Nutrition Program at the U.S. Department of Agriculture, are analyzing and interpreting data made available by the most recently completed USDA nationwide food consumption survey.

A few examples of what we are learning about the food consumption behavior of individuals in the United States include that 39 percent of Americans eat three times in a day, 28 percent four times in a day, 14 percent five times, and 11 percent eat six times or more during a day. During a one-week period, only half of all surveyed American households reported consuming cheese in some form; three-fourths used a ready-to-eat cereal at least once; and 71 percent used luncheon meats or frankfurters at least once. Forty-two percent of all children 4-6 years of age are reported by their mothers to have consumed a sweetened baked product at least once per day.

When purchasing food in the grocery store, consumers confront as many as 10,000 attractive, and confusing, options. A comparable difficulty arises when food is consumed away from home, as an increasing proportion of the U.S. population is doing on a regular basis. The issue, therefore, is how to select foods that meet nutritional needs while satisfying cultural, economic, and other concerns. To be sure, a food is rarely selected just for its nutritional value; but more and more people are making nutrition an important consideration in their food choices. Time constraints, convenience, attractive packaging, and appetite appeal still tend to override nutrition. But public interest in, and acceptance of, information about nutrition is growing.

Our generally sedentary lifestyle makes it necessary that each of us carefully balance our nutrient and energy (i.e., calories consumed as food) intakes. Since surveys repeatedly show that an increasing proportion of the U.S. population is overweight, the balancing of calorie intake with expenditure is obviously an elusive goal. Its achievement requires either a vigorous emphasis on exercise and energy expenditure, or a decrease in food consumption, or both. Personal food preferences and an awareness of the nutritional values of various foods can

be combined with relative ease, however, when an individual is motivated to reduce energy consumption.

Information on food consumption patterns and data pertaining to nutrient intake are being used by us to underpin nutritional messages and food guidance materials that are being developed for the public at large. The goal is to better understand what the American public is eating and what implications this has for national health.

The data that personnel of the Department of Nutrition and Food Sciences are analyzing are part of a Nationwide Food Consumption Survey, which is conducted at regular intervals by the USDA's Human Nutrition Program. We are currently concerned with data on food used during one week by over 15,000 representative households in the U.S. In addition, food consumption data were obtained for 34,000 individuals in these households for a three-day period. Each individual member of the household recalled for an interviewer the food eaten during the day prior to the interview and recorded similar information about the food eaten the days of and following the interview.

We found that the average caloric intake of all the individuals (taken from spring data) appeared to be less than the average suggested by earlier surveys. Adult women averaged 1,700-1,800 kcal, while men reported consuming about 2,500 kcal. This unexpected result raised several important questions. One of them centered around the known tendency of individuals to under report such items as alcoholic beverages and specific types of foods such as those high in concentrated fats and/or sugars.

Individuals with decreasing caloric needs must pay special attention to substituting highly nutrient-dense foods for highly calorie-dense foods. Foods rich in refined sugar and/or fat or alcohol exemplify the "calorie-dense" designation and are often poor in other nutrients. Foods that contain substantial quantities of various nutrients compared to their calorie content are considered to be "nutrient-dense."

Of the energy calories reported by survey participants, about 40 percent were derived from fat and almost 17 percent from protein. In general, intakes of protein were above the Recommended Dietary Allowance. These data further substantiate the results of other nutritional status surveys, which have indicated that access to protein is not a problem for most U.S. citizens.

When food-consumed data were evaluated for nutrient composition and compared with standards for nutrient intakes, females from twelve to sixty-four years of age were seen to be at some nutritional risk because their reported intakes of calcium, iron, magnesium, and vitamin B_6 were less than recommended. Women in these age groups generally averaged 21 percent or more below their Recommended Dietary Allowances for these nutrients (Table 1). Magnesium and vitamin B_6 intakes appeared to be somewhat marginal for males; however, interpretation of these data must be tempered by the tentative nature of the available food composition data for these two nutrients. In general, vitamin C intakes averaged 50 percent above the Recommended Dietary Allowances, indicating this is not a nutrient of concern.

We also evaluated the nutrient density of the diets (that is, the amount of nutrient per energy unit) in conjunction with the more traditional approach (that is, the amount of nutrient intake for the various age/sex classifications). Our goal was to derive a basis for assessing the nutritional quality of average American diets by examining and comparing each to the dietary allowances relative to the calories that are provided. When this approach was applied in the analysis of the survey, men and women were found to be consuming similar diets except for their intakes of vitamins A and C (Figure 1). Women reported consuming more of these nutrients on a per calorie basis than did men. While similar percentages of men and women said they consumed foods considered to be good sources of A and C, men generally did not increase their intakes of these food items in proportion to increases in calories. (Foods that are highest in these nutrients are in the fruit and vegetable category.)

The composite data indicate that, per 1,000 kilocalories of diet consumed, the average 1977-78 American diet met or exceeded dietary allowances for protein and phosphorus, and vitamins A, thiamin, riboflavin, niacin, B_{12}, and C. Those diets, however, provided only 80 to 95 percent of the recommended allowances for calcium, iron, magnesium, and B_6 (Figure 1).

The nutrient density ratings of the diets for many of the nutrients did not appear to change significantly with age. Protein, phosphorus, thiamin, niacin, and B_6 intakes per 1,000 kcals remained relatively constant across all age groups. Calcium and riboflavin intakes declined slightly while magnesium and vitamin B_{12} intakes increased slightly with increasing age. In contrast, we found that consumptions of vitamins A and C per 1,000 kcals rose sharply with increasing age, particularly among females. Apparently, as individuals age, they decrease their intakes of milk products (high in calcium and riboflavin), but consume more nutrient-dense diets by including larger amounts of fruits and green leafy vegetables. This hypothesis was substantiated by the food consumption data.

Our analysis of the USDA's household and individual consumption survey data indicates that members of the American households surveyed were consuming diets that averaged very similar nutrient contents per unit of energy. Certain nutrients (iron, calcium, magnesium, and B_6), when compared with standards, appeared to be low in the diets of certain age/sex classifications.

As we at USU continue to analyze the data accumulated by the USDA survey, we will be sharing the information on food and nutrient consumption patterns with extension personnel and other nutrition professionals. One result is that nutrition-education programs can more realistically address important health issues by focusing on areas of nutritional concern identified in the survey data. Our experience with the data summaries has also stimulated us to question how future surveys can be conducted more efficiently to insure accurate data collection and rapid analysis. Graduate students and faculty members are considering these problems from several approaches.

ABOUT THE AUTHORS

Bonita W. Wyse is Associate Professor of Nutrition, and Director of the Medical Dietetics Program at USU.

Carol T. Windham is Research Associate and a PhD candidate in the Department of Nutrition and Food Sciences.

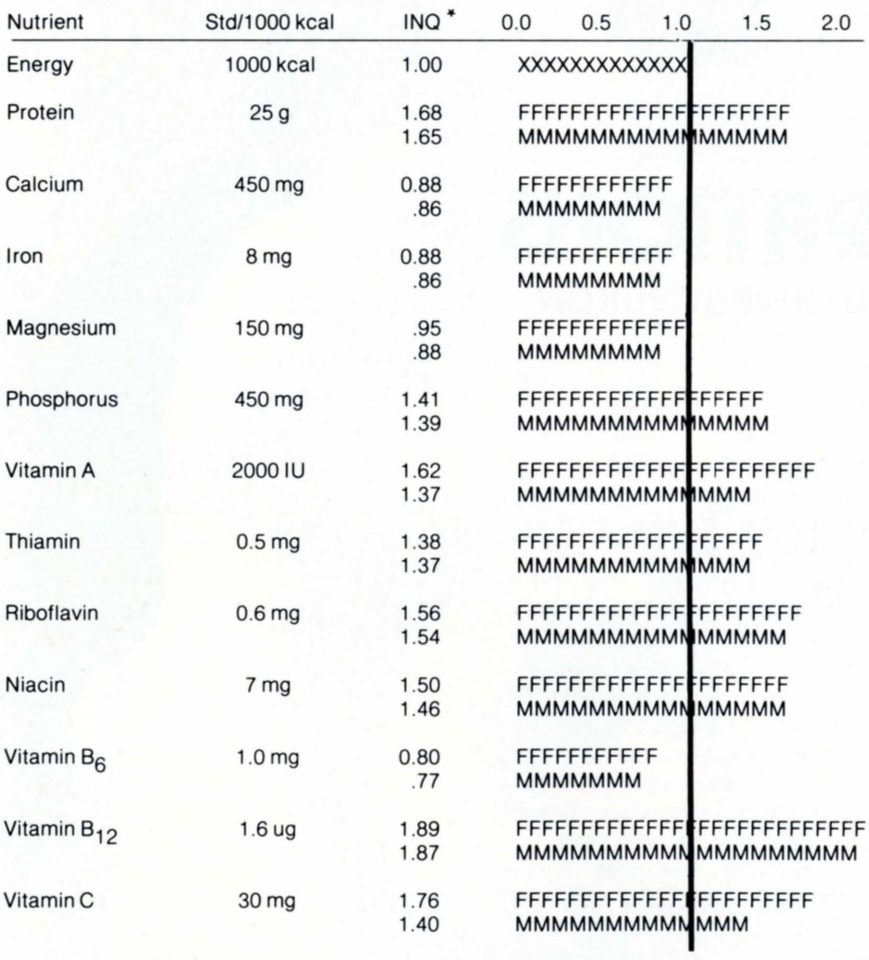
R. Gaurth Hansen is Provost and Distinguished Professor in the Departments of Nutrition and Food Sciences and Chemistry/Biochemistry.

Table 1. INTAKES[a] BELOW[b] RDA (1980)[c,d]

Sex-Age (years)	Calcium	Iron	Magnesium	Phosphorus	Vitamin A Value	Thiamin	Vitamin B6	Vitamin B12
Male-Female:								
Under 1								
1-2		****						
3-5	**	***	*				*	
6-8			*				*	
Male:								
9-11	*		**				*	
12-14	*	**	**				*	
15-18	*	*	***				*	
19-22			**				**	
23-34			**				**	
35-50	*		**				***	
51-64	**		**				***	
65-74	*		**				***	
75 and over	**		***				****	
Female:								
9-11	**	*	**				**	
12-14	***	****	***	*			***	
15-18	****	****	***	*			****	
19-22	***	****	****		*	*	****	
23-34	***	****	***			*	****	
35-50	****	****	***				****	
51-64	****	****	***				****	
65-74	***		***				****	
75 and over	***		***				****	*

[a] Intakes for all sex-age groups met RDA for protein, riboflavin, niacin, and vitamin C
[b] Below by: *1-10%, **11-20%, ***21-30%, ****30% or more
[c] Average intake, 1 day, Spring 1977, 48 states
[d] USDA Nationwide Food Consumption Survey 1977-78, B. Peterkin, Western Hemisphere Nutrition Congress

Figure 1. NUTRIENT DENSITY PROFILE
AVERAGE FOOD CONSUMPTION PER 1000 KCAL
Females (F) and Males (M) over 3 yrs.



*Index of Nutritional Quality

THOMAS D. BUNCH and MANFRED HOEFS

HORN ABERRATIONS

IN DALL SHEEP OF THE SOUTHWEST YUKON

DALL SHEEP ARE THE ONLY WHITE NORTH AMERICAN WILD SHEEP. Although related to the Rocky Mountain and Desert Bighorn sheep, their appearance and range are very different (Figure 1).

Horn aberrations in Dall sheep living in the Kluane Lake area of southwestern Yukon were first observed in the mid-1930s (Figure 2). During the early 1960s, sporadic sightings of similarly malformed horns were reported to Canada's Yukon Wildlife Branch. As hunting pressure in the area continued to increase, however, outfitters (around 1975) requested an investigation by Yukon Wildlife Branch personnel of rams with horn aberrations.

In 1977 ten different rams were seen to have aberrant horns. Between September 1977 and July 1979, six rams with deformed horns were collected by personnel of the Wildlife Branch. An additional six rams with abnormal horns were collected by hunters during those years. In July of 1980, three scientists (Thomas D. Bunch, PhD—team leader; Homer S. Ellsworth, MD; and Robert Glaze, DVM) were requested by the Foundation for North American Wild Sheep to cooperate with the Yukon Wildlife Branch in a further investigation of possible causes of the horn deformities. One ewe and seven rams (Figure 3) were therefore collected by means of a helicopter.

FIGURE 1.
The Dall sheep is principally located in Alaska and is the only white North American wild sheep. Their southeastern range extends into the Yukon. The Dall sheep are frequently referred to as thin-horned sheep, which delineates them from the more massive horned Rocky Mountain bighorn sheep.

FIGURE 2.
Horn aberrations in the Dall sheep result in either a stumping off of the horn (right horn) or a combination of stumping and torquing (left horn) that often lead to the terminal portion of the horn growing into the side of the head.

FIGURE 3.
Ram collected in the vicinity of Kluane Lake with stumped horn.

FIGURE 4.
Extreme torquing of horn often results in blindness, infection, or interference with eating as the tip of the growing horn comes into contact with the side of the head.

FIGURE 5.
Dall sheep with horn deformities have been reported in the area of Kluane Lake in northwestern Yukon. Several sheep can be seen running along the top of the cliff.

FIGURE 6.
Necrosis at the extreme tip of the horn core results in cavities being formed at the annual growth checks.

FIGURE 7.
Major portion of this core has become necrotic with a thin section of connective tissue separating the living from the dead bone.

FIGURE 8.
When large necrotic segments of the horn core are encapsulated within the sheath, they contribute to the stumping of the horn or in the torquing or twisting of the horn. (Note small portion of core in upper region of section horn.)

FIGURE 9.
Necrosis of the terminal portion of the left horn core has permanently altered the conical morphology of the normal (right) horn core of this ram.

FIGURE 10.
Past history of necrosis is permanently left in the pattern of each annual segment of horn growth. Four growth periods (four years) can be observed in this sectioned horn, with each section revealing past necrosis of the core.

FIGURE 11.
A thin cell membrane overlies the boney horn core and results in the formation of the keratonized sheath. The orderly laying down of the sheath results in a specific curvature of the horn. Once the mechanism has been altered, then excessive growth along one side of the horn may result in a greatly thickened wall of the sheath. Aberrant growth of the sheath is believed to be the principal factor involved when a horn becomes torqued.

he Problem

Two patterns of horn aberrations have een observed in the Dall sheep. In the ıore common type, the horn breaks way at the annual growth check, or ng, leaving the remaining horn as a mooth, conical protuberance (Figure 3). his stumped horn has led to such nimals being referred to as one-horned heep. Particularly in rams, both horns ıay be missing. In the second type, the roken horn undergoes a subsequent berrant growth of its sheath. This esults in an extreme torquing of the orn (Figure 4). The torqued or twisted orn will often grow into the animal's ye or its maxilla or nasal regions, ausing blindness, chronic infection, or n interference with mastication of food.

Horns in affected and nonaffected ams differ significantly in growth atterns. The non-stubbed-off horns of ffected rams grow at a noticeably lower annual rate than do horns of naffected rams. The implication is that ne growth processes in the intact horn f an affected ram is malfunctioning. As ight be expected, any growth of the emaining portion of the stubbed off orn of an affected ram is less than that f its intact horn.

The total Dall population in the study rea (700 square miles) is approximately ,300 sheep (Figure 5). The incidence of ffected rams appears to be about one ercent of the population, but the figure pproaches 15 percent when only the nature ram segment is considered. The ncidence in ewes is unknown since berrant horns are difficult to identify rom the air. Then too, at the time of ear when aerial surveys of ewes could e attempted, the ewes with lambs have ormed nursery bands and helicopter ntrusions could result in accident or njury to the lambs. During our 1980 ollection efforts, however, two solitary ewes were identified as having horn eformities and one of these animals vas collected. Even based on such ecessarily limited observations, owever, it is reasonable to suspect that ne incidence of affected horns in ewes ıay approach that in rams.

Hypotheses and Facts

Prior to the U.S. team's involvement, three hypotheses were formulated regarding causes of the horn aberration. One suggested that young sheep in the Kluane Lake region are especially prone to accidents, which could result in a breaking away of the horn sheath. The second proposed a disease similar to that of chronic sinusitis, which is decimating desert bighorn sheep (see UTAH SCIENCE pp. 97-103, 1978). The third alternative being considered was a genetic defect that structurally weakened the horn and thus made it prone to breaking.

Examination of the sheep collected in 1980, however, has indicated that an affected horn is predisposed to necrosis or death of part of the horn core prior to breaking. We believe this predisposition is somehow associated with freezing of the terminal region of the core. The segment of the core that becomes necrotic may be minimal or may include 1/4 of the terminal portion of the horn core (Figures 6 and 7). When a minimal segment is involved, a cavity is formed between one year's growth of the sheath and the next. The resultant structurally weakened sheath may then break away during a head clash with another ram. As a result, the older, more dominant rams would be especially prone to having stubbed horns. When a major area of the core becomes necrotic, it is walled off with connective tissue and sequestered from the remaining live bony tissue (Figure 8). At the point of separation, the sheath continues to grow and completely encapsulates the necrotic core. Later, the encapsulated core may induce a total collapse of the sheath and extreme torquing of the horn or a severing of a portion of the horn. When a segment of the core becomes necrotic, the alteration of its external anatomy is fingerprinted into the sheath of the animal's horn during successive annual periods of growth (Figures 9 and 10).

In a normal horn, a basal membrane overlies the core and produces cells that become keratonized, thus creating the sheath. The uniformity and rate at which these cells that form the sheath are laid down determine the type of curvature the horn will take. This membrane may also be altered in its function in an affected horn (Figure 11). The hypothesized alteration would cause the wall of the sheath to become greatly enlarged and thereby contribute to the torquing of the horn.

Remaining Questions

Why the horn core initially starts to die is still being investigated. One possibility is that a portion of the core is being frozen, even though the temperatures in the Kluane Lake area are considered mild for Dall sheep (which are commonly found in Arctic environments). Therefore, and since the horn aberration appears to be limited to the sheep of the Kluane Lake area, other factors obviously must also be considered as possible predisposing causes. One hypothesis is that either trauma or genetic factors may be reducing the blood supply to the horn core. That phenomenon could make the core susceptible to freezing and commence the sequence of events that results in a deformed horn. Research to define the primary cause will continue to be conducted by USU and Yukon Wildlife Branch personnel, with funding by the Foundation for North American Wild Sheep.

ABOUT THE AUTHORS

Thomas D. Bunch, Research Associate Professor of Animal, Dairy, and Veterinary Sciences and Research Associate of the International Sheep and Goat Institute, has conducted numerous studies on wild sheep of the world and was the first to identify and describe a major disease (chronic sinusitis) in the desert bighorn of southwestern United States. His other research areas include cytogenetics and various aspects of animal reproduction.

Manfred Hoefs is a Dall sheep specialist and Chief Biologist with the Yukon Wildlife Branch.

apprenticeship

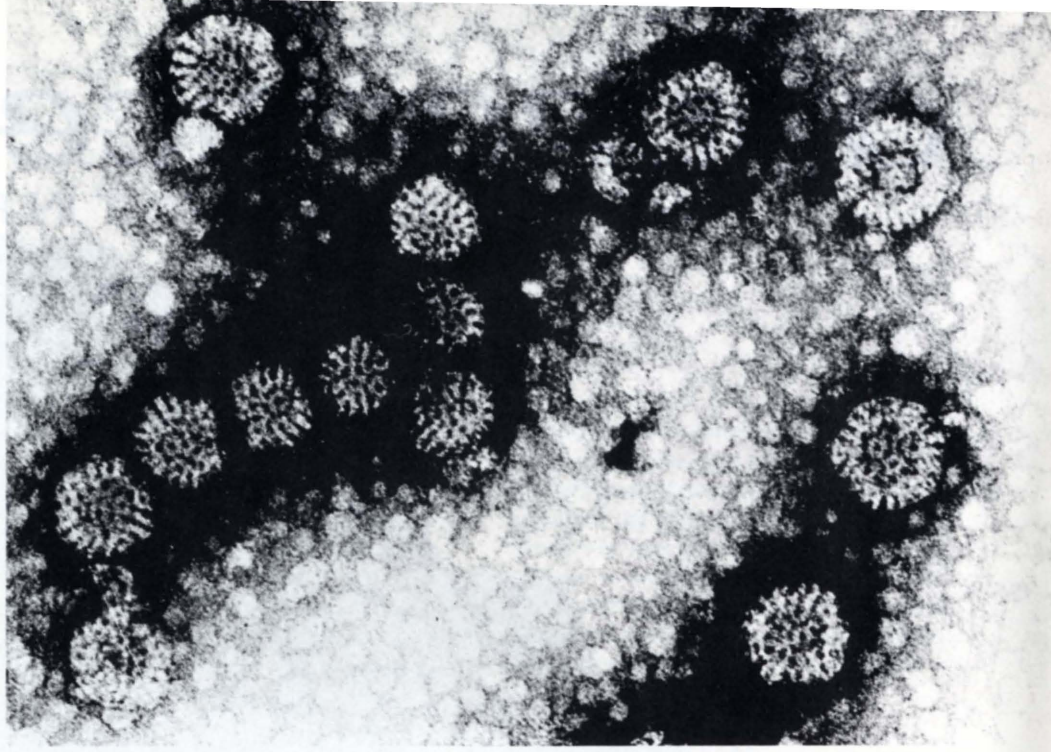
STUDENT INVOLVEMENT IN RESEARCH

Faculty and students find their research relationship mutually stimulating and rewarding— while society benefits.

TO STAY IN BUSINESS, ANY BUSINESS, YOU HAVE TO MAKE A PROFIT. That means you have to choose and manage your input so it optimizes your output at a minimum cost. And when your primary business is research, as it is for the Agricultural Experiment Station, an especially crucial input is people, and their ingenuity, dedication, and (ultimately) productivity.

So, within the Station, as within most university communities, the apprentice system continues to thrive. The main difference between today's applications and those of medieval times is that the apprenticeship is voluntary. But, precisely as before, without the apprentice system, the business would be in danger of collapse.

Valerie Madsen, student in the Animal, Dairy, and Veterinary Sciences Department, combs through a minute sea of microscopic cells for a single fertilized egg to be used in an ovarian transplant.



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VIRUSES

In virology, for example, several research projects would become virtually inactive without their student apprentices. As more people throughout the world begin to drink revitalized rather than fresh water, ways must be found to identify and quantify waterborne, disease-causing viruses. A major need is for an "indicator" virus—one that is abundant, universally present in sewage, and nonseasonal in occurrence. Ideally, the sought-after virus would also be nondisease producing, to limit chances of its being eradicated by a public health crusade.

One group of viruses, the reoviruses, gradually was recognized as having many of the sought-after qualities. Intrigued by the reovirus/water quality problems, two graduate students began to exchange ideas on possible solutions. One of them (D. Jack Adams), developed procedures that extracted unprecedented amounts of reoviruses from sewage samples. Almost simultaneously, the other (David Ridinger) proved that reoviruses prefer bovine kidney cells to any of the other sources of sustenance commonly offered viruses. In total, it required four years of persistent, thoughtful work to convert a concept into unequivocal data.

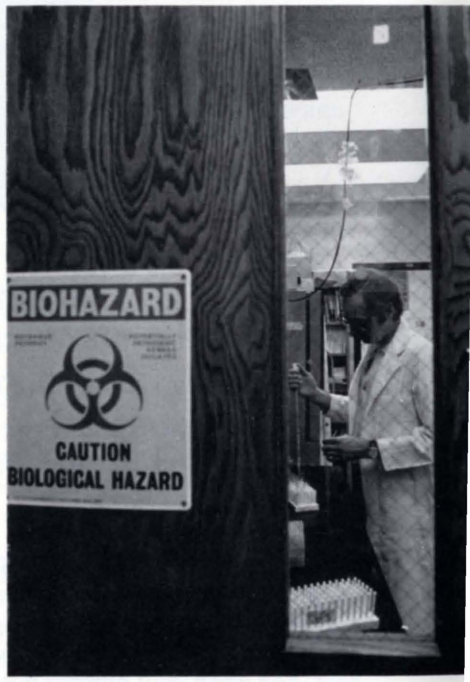
Next, the insights achieved by these two students and their faculty advisors had to be combined with a method (perfected by Experiment Station staff) for identifying reoviruses under a microscope. The resultant assay "package" was then applied to samples taken monthly from the Hyrum, Utah sewage treatment plant, with sampling being done by a work/study student.

All virology programs (rotaviruses and gastroenteritis; ways to inhibit disease-causing viruses; animal nutrition and rotavirus infections; viral implications of using sewage in irrigation projects; and clinical identification of viral diseases) rely to some extent upon the inventive thinking of students and their hours of painstaking labor.

In rotavirus investigations, for example, Allen Carter was instrumental in discovering that rotaviruses can produce gastroenteritis only while they retain both of their outer coats. Since rotaviruses are the causative culprits in about 50 percent of all cases of infant diarrhea, substantial time and energy are going into projects that may give clues as to effective control measures.

Donald F. Smee, a 1980 graduate student, coauthored (with three professors) a paper describing experiments with antiviral substances. The paper, which won a share of first place honors at the annual meeting of the Intermountain Branch of the American Society for Microbiology, described research in which Smee and his professors identified the effects of these chemicals on rotaviruses.

Among the students who have had an opportunity to participate in research as undergraduates are Fred Hayes and Martin Peterson. This early start in research has enabled them to compete exceptionally well in the job market. Fred is head electron microscopist in a large government laboratory and Martin, who has a MS degree, is head of an industrial virology group. The student/apprentice system thus produces indirect as well as direct benefits.



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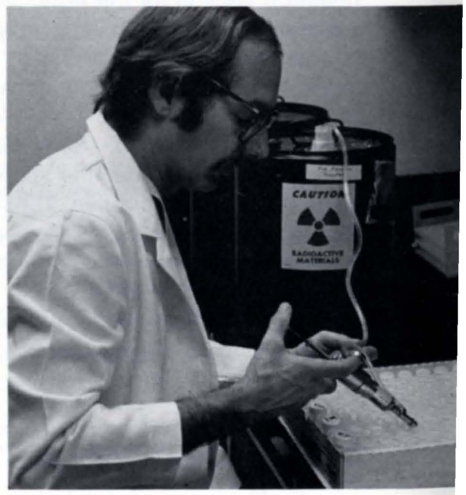

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1. Electron micrograph of rotavirus by graduate student Corey Mjaatvedt.

2. and **3.** For Scott Clark, working with biohazardous materials was part of the trek to a doctoral degree. USU's graduate students learn to be scientists by probing their own potentials through independent research projects. Simultaneously, they help solve society's problems and add to our understanding of our world.

4. Instrumentation perfected by Kris Havstad turned range-grazing cattle into data generators.

5. New forage measurement techniques used by an undergraduate student promise increased efficiency in one type of range research.

RANGES

Rangeland research is equally dependent upon an apprentice approach. The project on which Kris Marcusen (a senior in Range Management) has been working as a research aide is representative. The data gathered at our Tintic Range Research Station by Ms. Marcusen will help give land managers a practical tool with which they can accurately assess how much forage is growing on a range. The height, weight, and basal ground coverage measurements Kris is making on crested and western wheatgrasses growing under range conditions will be correlated by the scientist in charge of the project with similar data collected elsewhere. Ideally, Kris' efforts as a technician will contribute to an abandonment of the time-consuming clip, dry, and weigh method of estimating forage production.

In contrast to the extensive supervision given undergraduates, graduate students take responsibility for entire sub-projects that may require two to three years from concept to completion. Working as partners with their major professors, these candidates for MS or PhD degrees are expected to (and do) show imagination, initiative, and persistence.

An example is Kris Havstad's efforts to measure the energy costs imposed on a grazing animal as the season wears on and forage on a range becomes less abundant. His PhD research is one phase of several investigations that are trying to determine which species of animals, in what combinations, and at what stocking rates will optimize the animals' nutritional status while sustaining range plant productivity.

From reports of completed research, Kris learned that grazing animals tend to compensate for decreasing forage availability by grazing longer per day and/or taking more bites per minute. Both these strategies require the animal to spend metabolic energy. The questions for which answers are being sought are: how substantial is this expenditure and how does it vary through a grazing season?

Unfortunately for Havstad, neither his need to know nor his ingenuity in creating and testing equipment inclined the cattle toward cooperation. It took from March to June to convince the animals to accept their back-packs which carried the sophisticated equipment used to measure the energy expended. But acceptance did come—and so did the data. In 1980, Kris collected comparable information from similar cattle confined to stalls but fed the same crested wheatgrass diet. Analysis and eventual publication of his research results will not only fit a vital piece into our larger jigsaw puzzle, it will also give researchers elsewhere new tools for gauging, and insights into, the energy flows that characterize range ecosystems.

If suddenly deprived of student collaboration and help, rangeland research on this campus would suffer greatly in both quantity and quality. But with the apprentice approach, benefits should continue to accrue to everyone who uses rangelands and their products.

1. Nutrition research often requires tedious hours of laboratory work. Students thus learn the hard lesson that creative initiative in a science comes to fruition only through such an energy investment.

2. Students and scientists involved in weed research routinely consider all possible routes to a solution: new equipment, pesticide application, and biological controls.

HUMAN NUTRITION

Whether the project is a fundamental biochemical study of human metabolism and requirements for a specific nutrient, or the development of innovative ways to communicate nutrition information to consumers—the rate of progress often depends on student apprentices.

For example, Joan Howe Walsh, a recent PhD candidate, worked out ways to adapt a new analytical method (radioimmunoassay) to measure pantothenic acid in foods. A MS degree student, Nedra Christensen, defined the status of pantothenic acid nutrition in the elderly. The preliminary results of these studies helped the scientists involved obtain a $200,000 grant for additional food analyses. The results will include a long-needed knowledge of pantothenic acid nutrition in the U.S. population.

When undergraduates indicate an interest in research, they are encouraged to participate in work that will show them that the frontiers of knowledge are pushed back only with an intense commitment and substantial individual effort. Initially, the undergraduates (and an occasional promising high school student) are involved in research as supervised assistants.

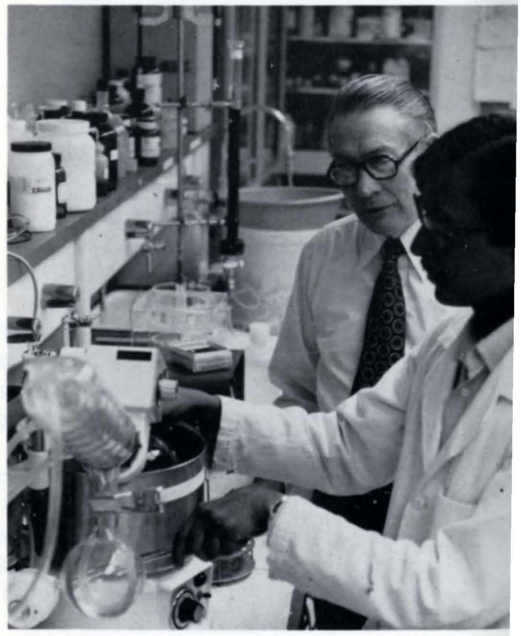
1

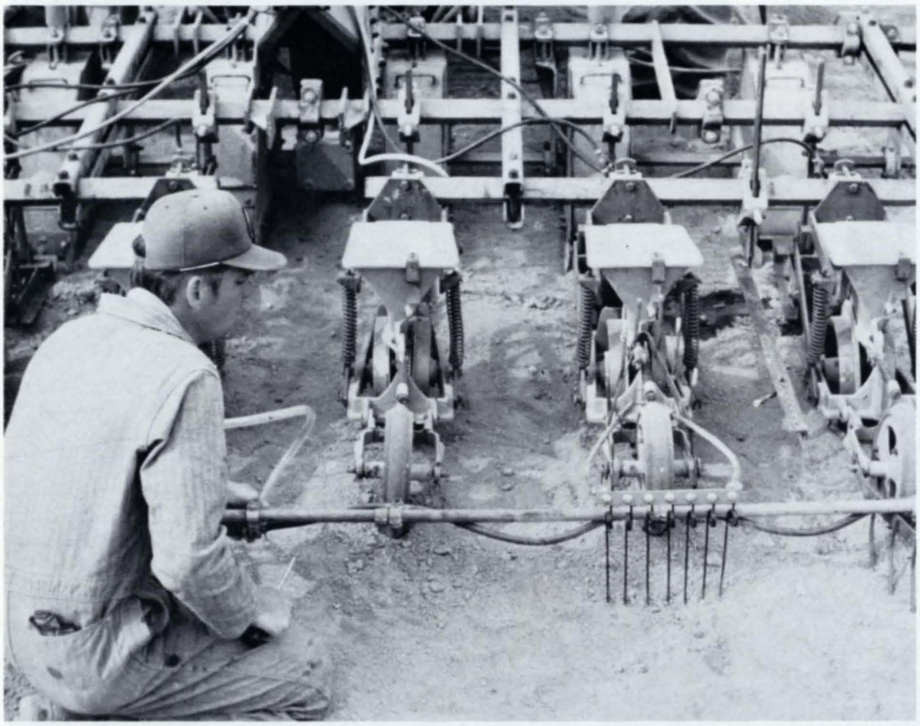
National Recognition

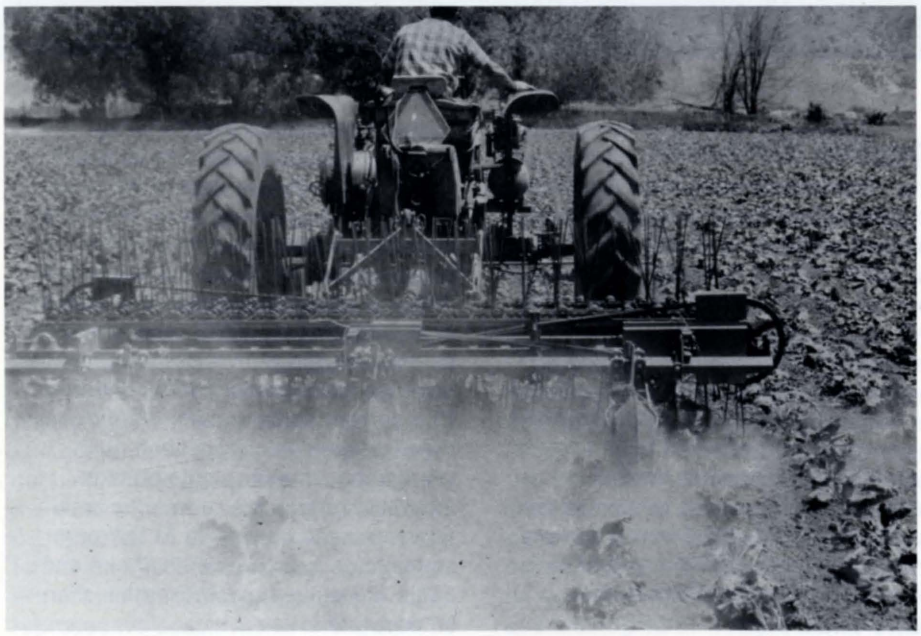
Utah State University and its faculty have received much national recognition for developing a method of communicating nutrition concepts called nutrient density or the Index of Nutritional Quality. One student, Kristy Mahn, using computers, has explored alternate nutrition labeling formats building on this concept. The Food and Drug Administration is seriously considering a nutrient density format to replace the current nutrition information on food labels.

A nutrition education curriculum for the elementary grades that was created and evaluated by USU graduate students has been commercially produced and is being considered by many states for use in their public schools. The concept has also been used as the basis for nutrition programs in high schools, for low income minority groups, and for the general public. None of these educational advances would have been realized without the input and initiative of bright and talented students.

Faculty and students find their research relationship mutually stimulating and rewarding while society benefits. Many graduates of the USU/UAES human nutrition program have been sought by prospective employers long before their degrees are completed.







2 WEEDS

Whether the weeds are in a 100-acre crop or a backyard garden, the first choice has to be between eradication and control. New tillage tools can sometimes be the answer for established weeds. A USU student, Clair Erickson, designed and tested a special cultivator knife that can destroy seedling weeds in row crops and simultaneously apply a band of selective herbicide to maintain weed-free conditions for the remainder of the growing season. Student/apprentice investigators frequently assist in evaluating tillage equipment developed elsewhere and in determining how the units may fit into overall pest management programs for Utah conditions.

In other cases, a weed has to be known more intimately before its unwanted effects can be overcome. (Wild morning-glory, whitetop, Canada thistle, and Dyer's woad exemplify this category.) Several undergraduate and graduate students have devoted thought and energy to this end. For example, the graduate study of Bill Varga (who now directs the Farmington Field Station) remains our best source of information about Dyer's woad, an important weed in Utah and several adjoining states. Varga presented data on the weed's growth habits, environmental responses, potentials for new infestations, and possible control procedures.

Robert Wood, as an undergraduate, discovered that snow speedwell germinates principally beneath the snow cover of winter. It thereby escaped the usual methods of controlling weeds in small grains and was able to exert its yield-depressing influence. His observations led to a modification of control methods so that growers now can effectively reduce its effects on small grain yields.

Numerous students have studied the wild oat weed problem over the past decade. Ray McAllister and Steve Dewey pioneered the concept that the awn of wild oat insured the survival of the species by forcing an early seed-drop. Landowners thus are unable to remove the weed from fields of other grains early enough to prevent its presence the following year. The same students also described how the weed could infest fields previously wild oat free.

1

ANIMAL AGRICULTURE

Cancer

With a naturally occurring animal cancer, the main goal is to develop therapeutic agents and clinical procedures applicable to human malignancies. Cancer eye in cattle, which is being investigated at USU, is closely analogous to human cancers of the lung, colon, breast, skin, uterus, rectum, and mouth.

Over a three-year test period, 70 percent of the cattle with primary cancers and without palpable metastases that were treated with a single intralesional injection of BCG (Bacillus Calmette-Guerin) cell wall vaccine underwent a regression or an arrest of their disease. Untreated animals died or reached advanced stages of the disease.

Student apprentices have acted either as technicians or taken responsibility for specific units of research. These individuals have thus had an opportunity to help identify and develop an immunotherapeutic agent that produces remarkably dramatic and apparently persistent remissions of cancer. They have also gained practical experience in handling and caring for large numbers of relatively aged animals.

The BCG cell wall vaccine, after proving effective in cattle, was used in West Germany as an adjunct to traditional surgery in human beings. The results attained there have generated a collaborative study (with the LDS Hospital in Salt Lake City) that should further substantiate the vaccine's general value as a human cancer treatment.

2

Breeding Programs

Other diverse animal-oriented research programs give additional undergraduate, graduate, and special students a realization that the animals involved are more than just "tools of their trade." In some cases, sheep are helping investigators understand environmental, physiological, and genetic mechanisms that control reproduction, growth, and other aspects of meat and fiber production. Separate but related research is more directly geared to the development of management programs, but with the same ultimate goal of increasing sheep productivity under today's conditions.

During the past 12 to 14 years, graduate students from Africa, South America, the Middle East, and elsewhere have joined those from Utah and other states in working at the Branch Research Station at Cedar City. These students have been instrumental in proving that breeding programs such as crossing the Suffolk and Targhee can increase meat production by one-third. One current student, Jack Whittier, a masters candidate from Utah, is investigating whether plants on high mountain ranges are more efficiently harvested and converted to optimum amounts of red meat when sheep and cattle are grazed together rather than on separate areas.

3

1. Intralesional injections of BCG vaccine were found to generally induce a regression or arrest of cancer eye in cattle.

2. Investigations of cancer eye in cattle have allowed students to learn anesthetizing techniques along with insights into the use of animal disease models as research tools.

3. By crossing Suffolk and Targhee sheep, students and their professors have improved meat production by one-third.

At Logan, in work related to the long-term studies at Cedar City, staff and students are comparing the capabilities of an exotic breed of sheep (the St. Croix) to those of a domestic breed and of their hybrids to lamb at six-month intervals. A significant proportion of the crossbred ewes in this program are producing over four lambs per year.

In research into the reproductive physiology of small ruminants (sheep and goats), student/faculty efforts are defining and testing ways in which the animals' endocrine systems can be manipulated to enhance their performance. Also, since sheep and goats are unique among farm animals in their reproductive sensitivity to changes in photoperiod (day length) and other environmental factors, they are acting as models for studies of environment/genetic relationships. The goal is to make photoperiod a controlled factor in reproduction.

Reproductive Research

A PhD candidate, Charles Ferris, has devised a method that identifies the receptor sites within the cells of the ovarian follicle on which one of the pituitary hormones acts. That hormone causes the follicle to ovulate and thus initiate subsequent phenomena essential to reproduction. Ferris' audioradiographic analysis technique allows him to identify the types of cells within the follicle where the various phenomena occur. It also facilitates studies of the effects of season of year and stage of reproductive cycle upon the incidence of the receptor sites.

Both sheep and goats, but particularly sheep, constitute excellent models for cytogenetic research. Established breeds or subspecies of sheep vary in chromosome number from 54 to 58. Some subbreed populations have numbers as low as 48. Groupings based on the various chromosome numbers are interfertile. The diverse chromosome numbers and the interfertility of sheep allow staff and students to study the influence of chromosomal modifications on physical and physiological abnormalities. The research results are applicable not only to sheep and goats but to many other species of animals, including man.

THE INDISPENSABLE SYSTEM

For the Agricultural Experiment Station, the student/apprentice system is indispensable, as evidenced by the above examples and dozens of others that could be drawn from the remaining Station programs. Without the inputs of its enthusiastic, volunteer apprentices, the Station's research business would inevitably show a decline in its production of profits (new knowledge). And aspiring scientists would be hard put to gain experience in the practice of their chosen discipline.

Migrants & Community Participation

STEPHEN H. KAN

THE NEW (1970s) PREFERENCE of U.S. citizens for nonmetropolitan living did not exclude Utah. In this state, migrants who moved into nonmetropolitan communities after 1970 differ significantly from the oldtimers (Stinner et al. 1978). They tend to be younger and more highly educated. They are less likely to be widowed, less likely to own land, more likely to be politically independent of any party affiliation, and less likely to be Mormon than either previously settled migrants or native residents. With these differences already defined, we decided to investigate two standard measures of social integration as they are operating in nonmetropolitan Utah communities.

Our data came from a 1975 survey of the residents in eight Utah communities. The residents were first classified into one of three categories: recent migrants, settled migrants, and natives. To be considered a native, an individual had to have been born in the community in which he or she was residing at the time of the survey and to have had no other residence in his or her residence history. Settled migrants had entered their current community before 1970. Recent migrants had migrated into the community after 1970. The year 1970 was our cut-off point because it is generally considered to mark the start of the population movement toward nonmetropolitan areas. In addition, previous studies have indicated that integration into a community usually occurs after five years of residence (Lowry 1966).

To simplify, we emphasized just two aspects of social integration: community attachment and willingness to help improve the community. Community attachment was measured in terms of: feeling of acceptance, community satisfaction, participation in community events during the year prior to the survey, kinship ties, and friendship ties (Tables 1 and 2). Assessing the respondents' willingness to give help for community betterment involved seven items (see Table 3).

The residents' feelings of acceptance were certainly associated with their migrant status (Table 1). As the table indicates, the relationship is highly significant ($p < .0001$) with a strong association (Gamma = -.438). The longer the period of residence in the community, the more likely is there to be a sense of acceptance. For example, only 42.7 percent of the recent migrants said they felt fully accepted by the community, while 79.4 percent of the natives indicated full acceptance.

When community satisfaction, participation, kinship and frienship ties were categorized by migrant status, certain substantial differences were apparent (Table 2). Predictably, recent migrants reported being less satisfied, and indicated much weaker kinship and friendship ties than did the oldtimers. On the other hand, no significant differences in participation in community events could be correlated with the various migrant categories. Indeed, the recent migrants had a mean participation score slightly higher than those of the other two groups.

In terms of willingness to promote community betterment, all residents were more willing to invest activity to solve community problems than to make monetary contributions or accept leadership responsibilities (Table 3). Among the three monetary options included in the study, "give two hours' pay" was the most acceptable. Local sales tax increase, give a half day's pay, and act as chairman of a committee lagged in favorable responses.

When each of the items indicating willingness was cross-tabulated by migrant status, six out of the seven were significant at least .01 level. And in this regard, recent migrants were significantly more willing than settled migrants or natives to help their community solve its problems through various activities including leadership responsibilities and monetary contributions, with the exception of "give a half day's pay."

Is Utah unique?

Previous, more comprehensive studies (Speare et al. 1974) had showed that recent migrants were more dissatisfied with their communities than were residents of longer standing. They were also found to participate less in voluntary associations (Sharp 1954). Other studies have indicated that migrants' levels of social participation were lower, but they seemed more likely to hold leadership positions in the organizations they did join (Blizzard and Macklin 1952).

In Utah, too, recent migrants to nonmetropolitan Utah communities were less satisfied with their community than were the long-established residents. On the other hand, their levels of social participation were slightly higher than those of their counterparts. More importantly, the recent migrants were much more willing to help improve their community through various kinds of activities and contributions. These characteristics may be associated with socioeconomic and demographic factors. Recent migrants tended to be younger, more highly educated, more energetic, and so forth. Therefore, though they often demanded more community facilities and services (especially if they had just fled a metropolitan complex), recent migrants may be crucial to the viability of their communities.

Less satisfied than other longer residents, recent migrants were significantly more willing to donate their time, money, and responsibility toward solving community problems.

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ABOUT THE AUTHOR

Stephen H. Kan completed MS degrees in Applied Statistics and Sociology at Utah State University, and has recently completed the requirements for a PhD in Sociology, also at USU. He is presently employed as a statistician-demographer at the Utah Department of Health in Salt Lake City.

TABLE 1. Feeling of acceptance by migrant status

Feeling of acceptance	Migrant status in percent: Recent In-migrants	Settled In-migrants	Natives
Fully	42.7	71.0	79.4
Partially	44.9	26.7	20.1
Not at all	8.0	2.3	0.5
Total	100.0	100.0	100.0
(N)	(301)	(487)	(214)

$x^2 = 78.29$
$p < .0001$
Gamma = −.438

TABLE 2. Community satisfaction, participation, kinship and friendship ties in terms of migrant status

Dependent variables	Mean: Recent In-migrants	Settled In-migrants	Natives	Source	Analysis of Variance: D.F	Mean Square	F	Eta Square (n2)
Community satisfaction	5.08	5.99	6.47	Between groups	2	135.72	39.47***	.074
				Within groups	993	3.44		
Participation in community events	2.06	1.97	2.32	Between groups	2	8.71	1.94	.004
				Within groups	944	4.50		
Kinship ties	16.26	30.83	46.58	Between groups	2	53363.20	60.56***	.118
				Within groups	910	881.13		
Friendship ties	45.48	70.00	75.74	Between groups	2	68703.94	64.91***	.126
				Within groups	899	1058.49		

***$p < .0001$

TABLE 3. Willingness to give help for community betterment by migrant status

Willingness to help	Migrant status: Recent In-migrants	Settled In-migrants	Natives	x^2	Gamma
Agree to a 1% local sales tax increase				11.56**	.196
Yes	37.0	31.9	22.4		
No	63.0	68.1	77.6		
Total	100.0	100.0	100.0		
(N)	(289)	(451)	(196)		
Give a half day's pay				5.41	−.017
Yes	36.7	31.0	39.8		
No	63.3	69.0	60.2		
Total	100.0	100.0	100.0		
(N)	(289)	(451)	(196)		
Give two hour's pay				9.67**	.137
Yes	52.6	41.2	42.9		
No	47.4	58.8	57.1		
Total	100.0	100.0	100.0		
(N)	(289)	(451)	(196)		
Act as chairman of a committee				11.58**	.186
Yes	38.1	27.5	26.0		
No	61.9	72.5	74.0		
Total	100.0	100.0	100.0		
(N)	(289)	(451)	(196)		
Serve on a committee				9.36**	.173
Yes	76.1	67.0	64.8		
No	23.9	33.0	35.2		
Total	100.0	100.0	100.0		
(N)	(289)	(451)	(196)		
Give spare time one evening per week				22.80***	.250
Yes	77.9	62.3	61.2		
No	22.1	37.7	38.8		
Total	100.0	100.0	100.0		
(N)	(289)	(451)	(196)		
Sign a petition				35.85***	.324
Yes	83.7	65.0	63.3		
No	16.3	35.0	36.7		
Total	100.0	100.0	100.0		
(N)	(289)	(451)	(196)		

**$p < .01$
***$p < .001$

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E. FRANK SCHNITZER and R. L. SMITH

IRON DEFICIENCY

DIAGNOSIS AND TREATMENT OF UTAH FIELD CORN

OF THE SEVEN MICRONUTRIENTS THAT ARE KNOWN TO BE ESSENTIAL for plants, only iron (Fe), zinc (Zn), and manganese (Mn) have been diagnosed as deficient in some Utah soils. Deficiency signs were first noted in a number of orchard crops 30 years ago but were virtually never seen in field crops. With time, however, more iron and zinc deficiency symptoms have been reported in field crops, especially corn and sorghum.

Micronutrients are so-called because the amount of each that is required for plant growth is small compared with nitrogen, phosphorus, or other major nutrients. For example, a 30-ton crop of corn will contain about 200 pounds of nitrogen, but less than 2 pounds of iron.

In corn, an iron deficiency produces interveinal chlorosis (yellowing) and a characteristic striping of the leaves (Figure 1). Unfortunately, a similar interveinal chlorosis and striping are also observed in corn that is zinc deficient (Figure 2). With practice, however, the chlorotic patterns produced by the two deficiencies can be distinguished. In either case, a severe deficiency will mean stunted growth or no plants at all.

An iron deficiency is seldom uniform through a field (Figure 3). This relatively spotty appearance necessitates sampling (either soil or crop) from areas within the field where the deficiency seems to occur separately from areas where deficiency symptoms are not seen.

FIGURE 1
Iron deficient corn. Note the narrow stripes of yellow or chlorotic stripes in the leaves.

FIGURE 2
Field corn showing the soil variability of iron deficiency.

FIGURE 3
Zinc deficient corn. Note the broad stripe of chlorotic or yellow tissue.

FIGURE 4
The effect of added Fe chelate (pot 49) on the growth of the Fe-inefficient corn mutant (Ys1/Ys1). Both pots contained the same soil with an initial DTPA-extractable Fe content of 4.0 ppm.

FIGURE 5
The effect of corn variety on growth in soil low in extractable Fe. The soil had a DTPA-extractable level of 5.0 ppm Fe. The pot no. 30 contained the Fe-inefficient variety (Ys1/Ys1) while no. 26 contained the Fe-efficient variety (WF9).

FACTORS AFFECTING IRON AVAILABILITY

How much iron is taken from a soil by plants depends upon a number of interacting plant, soil, and environmental factors.

Plant Factors

Plants vary in their ability to tolerate minimal amounts of nutrients in a soil. Varieties of a single crop—such as corn—may even differ in tolerance for low concentrations of available soil nutrients such as iron.

Soil Factors

The amount of iron available for plant uptake is poorly related to the total amount of iron compounds in a soil. It is more closely related to the solubility of those compounds in a particular soil environment. In general, the availability of iron for plant uptake from soil is sharply reduced when the soil pH is greater than 7.0 (neutral).

Most Utah soils are dominated by the alkaline earth carbonates, commonly called "lime." In fact, the iron deficiency problems associated with our arid, calcareous soils have long been called "lime-induced" chlorosis. In reality, however, the problem is the result of a combination of many factors such as the abnormally high levels of calcium, magnesium, carbonates, and bicarbonates.

Iron deficiencies may also be caused by high levels of other elements, including nutrients. This is particularly true of phosphorus (P) and the micronutrients: zinc (Zn), manganese (Mn), and copper (Cu).

Environmental Factors

Low soil temperatures and cool, wet weather similarly can decrease the availability of iron. Sometimes these effects are overcome when the weather warms and the soil dries. However, excessive soil moisture throughout the growing season caused by poor drainage or too frequent irrigation can produce chlorotic plants.

Detecting Iron and Zinc Deficiencies

Theoretically, zinc deficient corn and sorghum plants can be distinguished from iron deficient plants by noting the chlorosis pattern. The older leaves of zinc deficient plants are first to show the interveinal yellowing with the leaf margins becoming necrotic later (Figure 2). Iron deficient plants generally show the chlorotic striping on the younger leaves first, and as the deficiency becomes more severe, all new leaves are pale yellow (Figure 1). In field situations, however, it is often virtually impossible to determine if a plant is suffering from an iron or a zinc deficiency. Indeed, the plants may be deficient in both of the micronutrients since the solubilities of both iron and zinc compounds are influenced by similar chemical conditions.

To be reliable, a diagnosis must include correlation between soil test values and crop responses. If adding a given micronutrient to the soil produces a growth response in the crop, that micronutrient can be assumed to have been deficient, providing all other growth factors are at adequate levels. Correlating micronutrient concentrations in sampled plant tissues with yield responses is less reliable than correlating yields with soil test values. This is probably due to dust contaminating the surfaces of the plant samples despite careful washing. Some micronutrients are needed in such small quantities that minimal surface contamination of leaves can significantly increase apparent plant concentration values.

Soil tests separate soils into deficient and nondeficient categories by determining the critical level below which a crop will respond to micronutrient fertilization of the soil. With calcareous soils, the most accurate soil test that has been correlated with yield requires a chelate extraction of the micronutrients using diethylenetriaminepentaacetic acid (DTPA).

Levels of soil iron and zinc extracted with DTPA that are considered critical have been reported in calcareous soils of Colorado, California, and Kansas. Plants growing on a soil with a zinc concentration below 0.5 parts per million (ppm) will almost always respond to zinc fertilization. For iron, plant response to fertilization is typically seen when the soil concentration is below 2.5 ppm. Plants stop responding to iron fertilization when the soil level exceeds the 4.5 to 6.0 range.

Although soil deficiencies of iron and zinc are less successfully identified from plant tissue concentrations than by using soil test values, an analysis of plant tissue concentrations may help confirm a suspected iron or zinc deficiency. Field crops with an iron concentration ranging from 30 to 50 ppm are considered to contain a marginal amount of iron. Zinc concentrations in field crops below 20 ppm are generally categorized as deficiencies.

Plant analyses alone are not reliable indicators of micronutrient deficiencies because mineral concentrations in plant tissue change with age, tissue position on the plant, and with surface contamination.

CORRECTION OF IRON AND ZINC DEFICIENCIES

The commonly used soil application of zinc compounds is generally the most successful way to correct zinc deficiencies. Soil-applied zinc material remains relatively stable and may persist for several years. In contrast, foliar applications are effective only for the current crop and may require repetition during the growing season.

Recommended rates for zinc applications to the soil vary from 2 to 12 kg Zn/ha dependent upon soil test or leaf analysis results. The most effective way to apply zinc to the soil is by surface broadcast and mixing prior to planting. Sometimes banding below the seed at the time of planting is used, although a thorough mixing of zinc and soil (as obtained in the broadcast method) seems advisable.

Zinc sulfate, zinc oxide, and zinc chelates are equally effective sources of the element when the required application rate is low (less than 6 kg/ha). For soils needing high rates of applied zinc, however, the chelate form is the most effective. Zinc frits, a slowly soluble glassy material, is less desirable than the three zinc sources previously mentioned because its particle size slows production of available zinc.

Soil applications of iron amendments give much less satisfactory results than do soil applications of zinc compounds. Inorganic iron sources ($FeSo_4$, FeO) are easily oxidized and precipitated out of solution under alkaline conditions. The use of organic forms of iron (chelates) can partially solve the problem of iron reacting with the soil constituents and becoming insoluble. As a chelate, iron remains in solution longer and is more available for absorption by the plant. Sequestrene 138-Fe is the most stable form of iron chelate when the soil pH is greater than 7.0. Applying the chelated iron in combination with nitrogen fertilizers can increase the efficiency of iron uptake by the plants. The high cost of the chelate material, however, can make the

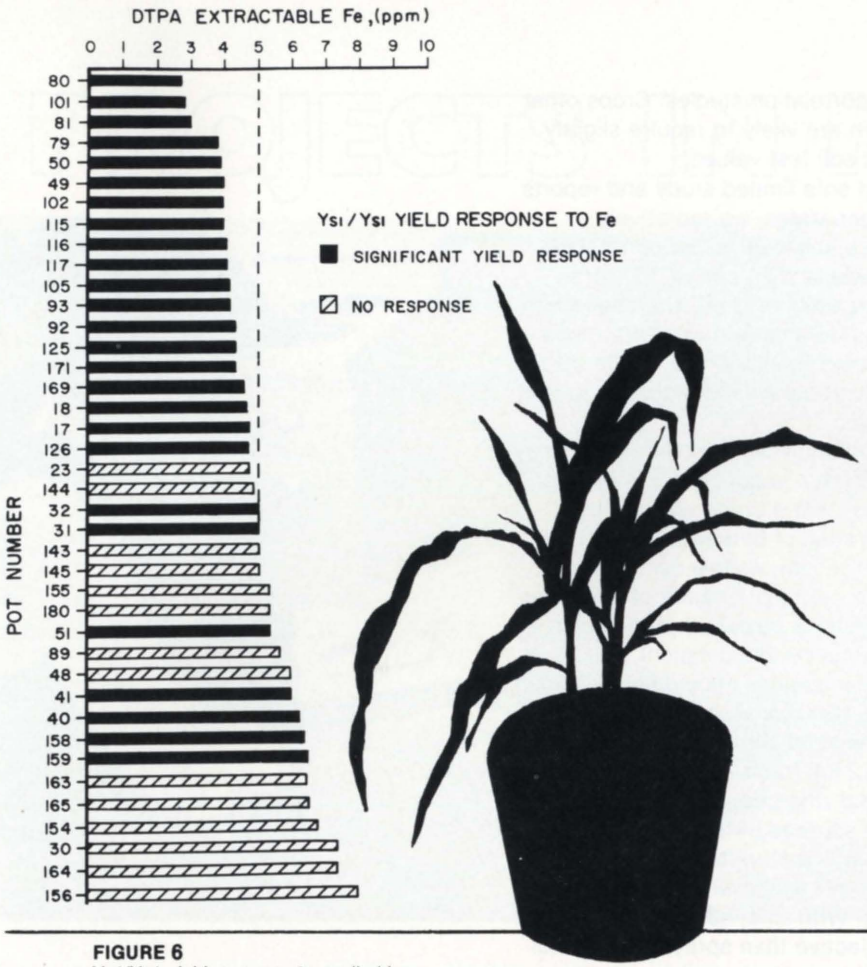

FIGURE 6
Ys1/Ys1 yield response to applied iron.

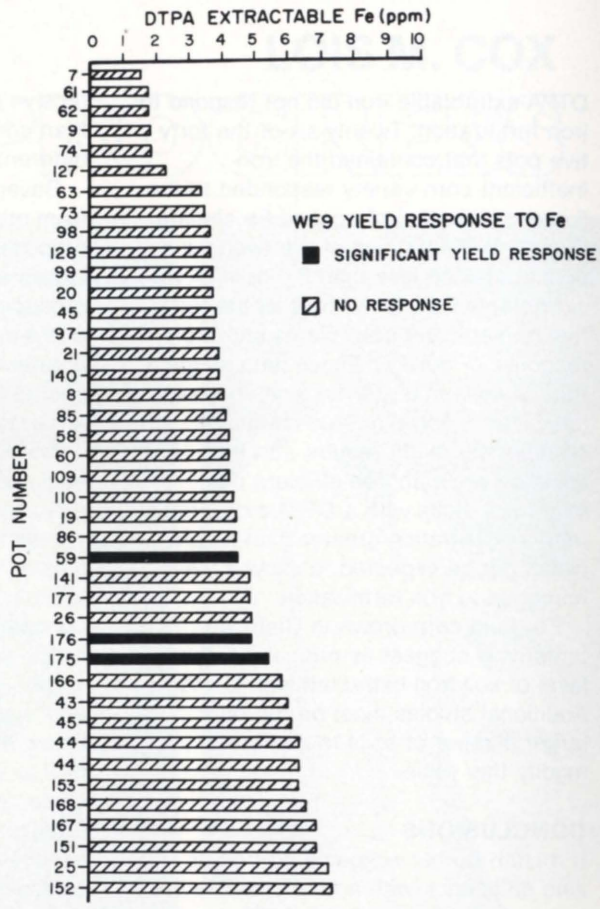

FIGURE 7
WF9 response to applied iron.

necessary application rate economically infeasible. Foliar applications of chelated and inorganic forms of iron have effectively corrected iron deficiencies of some field crops on calcareous soils in Utah's neighboring states. A foliar spray application of a 5 percent solution of $FeSo_4$ plus a wetting agent has been recommended at rates of 190 to 280 liters/ha in Colorado. The spray was applied every two weeks until the symptoms disappeared. Similarly useful foliar applications of Sequestrene 138-Fe were used at a rate of 1 1/2 pounds per 100 gallons. Plants should be thoroughly wetted when sprayed.

Crop species and varieties differ in their abilities to efficiently absorb and utilize micronutrients. Genetic variability allows some plants to be more efficient than others under a given set of environmental conditions. The ability to efficiently utilize nutrients is an important criterion to use in selecting crop varieties for particular situations. A corn hybrid developed in Utah (or under similar environmental conditions) would be a much better choice for a soil where micronutrient deficiencies are suspected than would a corn hybrid developed in the corn belt of the Midwest. Selection of a crop variety adapted to calcareous soils may preclude the need to apply a high priced iron chelate.

SOIL IRON CRITICAL LEVEL

To further define how best to diagnose and treat iron-deficiency problems in Utah soils, we used five soils from Millard County, Utah in a greenhouse study. These soils represented some of the state's characteristically low in iron soils. All five of the soils were divided equally into three groups and assigned one of three pretreatments: (1) One-third of the soils received no added iron and were stressed by successive croppings with corn and oats. (2) One-third of the soils were fertilized with Sequestrene 138-Fe and $ZnSO_4$ at 5 ppm (10 lbs/Ac) each. No crops were grown but the soils were kept moist for the same time periods as in pretreatment 1. (3) One-third of the soils did not receive any added iron or zinc during the pretreatment period.

Following the pretreatments, we used a randomized block experimental design to measure yield increased obtained in corn by adding more Sequestrene 138-Fe, the most efficient form of iron fertilizer on calcareous soils. Two corn genotypes, an Fe-efficient corn inbred (WF9) and an Fe-inefficient corn mutant (Ysl/Ysl), were planted. Applied to each of the three pretreatment soil groups were: (1) 5 ppm iron chelate plus corn inbred WF9, (2) 5 ppm iron chelate plus corn mutant Ysl/Ysl, (3) no iron additions plus corn inbred WF9, and (4) no iron addition plus corn mutant Ysl/Ysl. (See Figures 4 and 5.)

We also tested the effectiveness of the DTPA soil test for separating soils into deficient and nondeficient categories by comparing test values to yield responses to iron fertilization. Our results are summarized in Figures 6 and 7.

A significant yield response to iron fertilization was determined by an LSD statistical test at the 95 percent level of confidence. The black bars represent pots in which plants showed significant yield responses to iron fertilization, indicating that the soils had been deficient in iron. The crosshatched bars represent plants that did not respond to iron fertilization. Generally, plants grown in soils containing greater than 5.0 ppm

DTPA-extractable iron did not respond to iron fertilization. Twenty-six of the forty-five pots that contained the iron-inefficient corn variety responded to the 5 ppm (10 lbs/Ac) of applied Fe chelate (Figure 6). All but five of the twenty-six pots contained less than 5.0 ppm DTPA-extractable iron. Only three of the forty-five iron-efficient corn plants showed a response (Figure 7). These data suggest that on soils that are marginal in iron (less than 5 ppm), an iron-inefficient corn variety might require iron fertilization while an iron-efficient one might not. Soils with a DTPA-extractable iron concentration greater than 5 ppm would not be expected to show a yield response to iron fertilization.

For field corn grown in Utah, we tentatively suggest as critical a 5 ppm level of soil iron extracted with DTPA. Additional studies must be run on a larger number of soils to confirm or modify this value.

CONCLUSIONS

If a Utah farmer suspects an iron or zinc deficiency with a field crop, he has two management options: (1) He can grow crops that are more tolerant to low levels of iron and zinc. Switching from field corn to barley, for instance, would reduce the iron and zinc requirements and in most cases eliminate any chlorotic symptoms. Also, a different corn variety may have enough tolerance to the deficiency problem to grow well. (2) As a second option, he can "manage" the soil to maintain or improve its micronutrient level. This can include exercising more control over the soil moisture level, improving the drainage in lowlying areas, or limiting the amount of organic matter added to the soil. If micronutrient fertilization is made part of the management program, soil tests should be used to determine the available level of possibly deficient micronutrients. Fertilizers, including micronutrient amendments, should be applied only as necessary to avoid excessive chemical interactions in the soil and plants.

Our recommendations to correct deficiencies in corn are largely based on soil test values suggested for calcareous soils of Colorado, California, and Kansas. A DTPA extraction of soil that indicates 0.4 ppm or less of zinc can be used to identify soils that are deficient for corn growth. This value should be tested for Utah soils by extensive correlation studies. Crops other than corn are likely to require slightly different soil test values.

Based on a limited study and reports from other states, we tentatively propose a soil level of 5.0 ppm DTPA-extractable iron as critical for corn-producing soils of Utah. Utah soils with DTPA-extractable iron concentrations greater than 5 ppm would not be expected to show a yield response to iron fertilization.

Mineral analyses of plant tissues may help confirm a suspected iron or zinc deficiency. Field crops with an iron concentration of between 30 and 50 ppm in their tissues are considered to contain a marginal amount of iron. Zinc concentrations below 20 ppm in field crops are generally deficient.

Zinc compounds should be broadcast and then tilled, or they may be banded below the seed with an application rate of 2 to 12 kg Zn/ha. Zinc sulfate, zinc oxide, and zinc chelates are all good fertilizer sources of the element with the expensive chelated form giving the most satisfactory results when high rates are required. With zinc, soil applications are more effective than sprays because of their residual effect.

Iron fertilization is frequently a problem with alkaline soils because the iron in such soluble compounds as $FeSO_4$ and many iron chelates is soon inactivated when the soil pH exceeds 7.0. The only effective soil amendment for these soils is Sequestrene 138-Fe. The amounts needed for field crops may not be economically practicable to apply. Foliar applications of chelated and inorganic forms of iron can correct Fe deficiencies. A 5 percent solution of $FeSO_4$ or Sequestrene 138-Fe chelate at a rate of 1 1/2 lbs per 100 gallons are both effective. Foliar applications should be started early in the growing season and continued until the symptoms disappear.

ABOUT THE AUTHORS

E. Frank Schnitzer grew up in the mountains of Northern California, received a BS Degree in Soil Science from California Polytechnic State University, San Luis Obispo in 1978. He is a former Research Assistant at Utah State University with a MS in Soil Fertility.

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LOIS M. COX

PROJECTS IN PROGRESS

DIET AND CANCER IN SEARCH OF FACTS

WE ARE CURRENTLY BEING TOLD that 80 percent (or more) of human cancers are caused by something we eat, breathe, or otherwise contact. In other words—most human cancers are believed due to environmental factors.

Cancer of the colon (large bowel) has its highest incidence in countries having a western (U.S.) style culture. The most popular theory about its cause(s) cites dietary components: contaminants, additives, interacting food constituents, and effects of digestive tract bacteria on food constituents.

Contradictory observations, however, have left scientists with no consistent pattern of dietary factor/colon cancer linkage. The unargued truth is that virtually all malignancies result from a composite of biochemical, immunological, and/or viral processes, whose outcome depends upon chance combinations of genetic and environmental factors. Most researchers also agree that the role of diet in cancer may be related to the inevitably complex overall nutritional status rather than a single item.

From this viewpoint, today's dietary fat and fiber theories of aiding or abetting carcinogenesis are not mutually exclusive, since high-fat, highly refined diets are usually low in fiber and vice versa. The effects of diet can also be altered by the proportions and combinations of foods consumed at one time. For instance, fiber can change the digestibility of fat, while ascorbic acid increases the absorption of iron in non-meat foods. The type of protein eaten can also influence fat metabolism. In addition, the various types of fats, fiber, and proteins a person eats all influence the types and quantities of that individual's intestinal bacteria.

Why study the Utah population?

The Utah population has been of special interest to nutritional cancer theorists because the incidence of colon cancer in the state is the lowest in the nation and is only about one-half the average rate in the U.S. Similarly low incidence rates prevail in Utah for several other sites of cancer (e.g., breast, ovary, cervix, and prostate) and for cholesteremic heart disease. Theoretically, the diet of a population with such a low colon cancer rate would be expected to be high in fiber and/or low in fats. Unfortunately for the theorists, the Utah population does not conform to either the high fiber or the low fat theories as they are presently stated. Instead, Utahns consume high amounts of animal fat and protein but relatively little "crude" fiber (less than 100 mg per kilogram of body weight).

PROFILE OF THE PROFESSIONALS AND THEIR INTERDEPENDENCE

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1. Tammy Trimble, here beginning a dietary interview with one of the study's control subjects, is representative of the 19 Utah Cooperative Extension Agents throughout the state who have conducted the home interviews of patients and control subjects, collecting dietary data and specimens of foods preserved in the home. The Extension Service, based at USU, provided a major service through its staffing of the interviewing teams.

2. Dr. Joseph Street, Dept. of Animal, Dairy, and Veterinary Sciences, USU, is leading the investigations of food fiber chemistry and of the pharmacological effects of different fiber types.

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3. Dr. Ann Sorenson, formerly of the Dept. of Family and Community Medicine, U of U Medical Center, is now on the faculty of the School of Public Health of The Johns Hopkins University in nutritional epidemiology. Dr. Sorenson has been the principal investigator of this National Cancer Institute supported study; she continues to serve as a coinvestigator from her new position. Drs. Sorenson and Street originated the project plan and wrote the proposal.

4. Scott Bittner, a post-doctoral research fellow, Dept. of ADVS, developed the new methods for fiber characterization being used to study fiber types present in the major food items.

5. Home preserved foods collected during interviews are compared nutritionally to commercially prepared products. Dr. Arthur Mahoney, Dept. of Nutrition and Food Sciences, USU, and his student assistants conduct this work.

6. Dr. Dee West, the current principal investigator and Utah Medical Center epidemiologist, identifies the control subjects who are interviewed and studied along with colon cancer patients. He is shown here at the Utah Cancer Registry where patient records permit individuals to be identified and selected for this study.

7. Dr. Reed Geertson, a medical sociologist in USU's Dept. of Sociology, developed the telephone dialing system used to identify control subjects from the general population of Utah. He also conducts a telephone survey of home food preservation practices that allows a random collection of such foods for analysis in the study.

8. Mary Farley, Dept. of Nutrition and Food Sciences, USU, shown working at a computer terminal, is the nutritional analysis data coordinator. She works closely with the project biostatisticians at the U of U Medical Center.

9. Dr. William Standish, Dept. of Family and Community Medicine, Utah Medical Center, serves as the project's biostatistician. Here he is checking data in a computer analysis with Grace Chiu, a programmer in the Division of Biostatistics of the Department.

10. Biological specimen collection is coordinated by Kris Jouflas, U of U Dept. of Family and Community Medicine, shown drawing a blood sample from a study respondent.

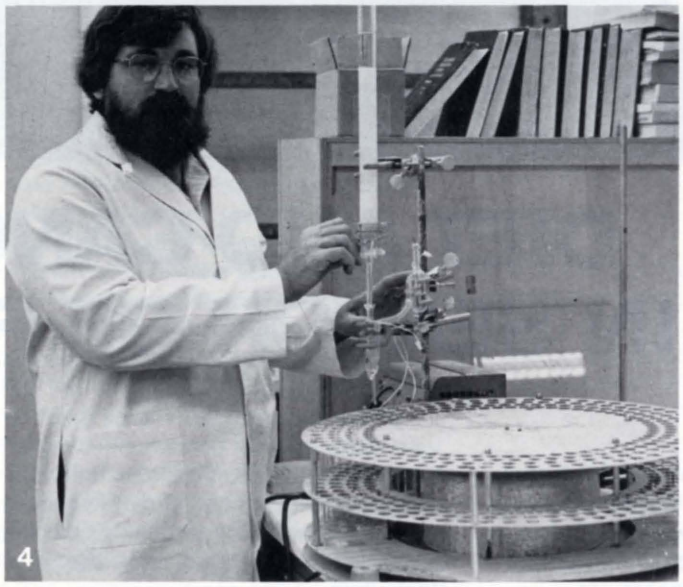
11. Serum samples collected from a subset of the colon cancer patients and control subjects are analyzed under the direction of Dr. Owen Ash, Director of the U of U Medical Center clinical chemistry laboratories. Analyses include lipids, trace elements, and vitamins C and A.

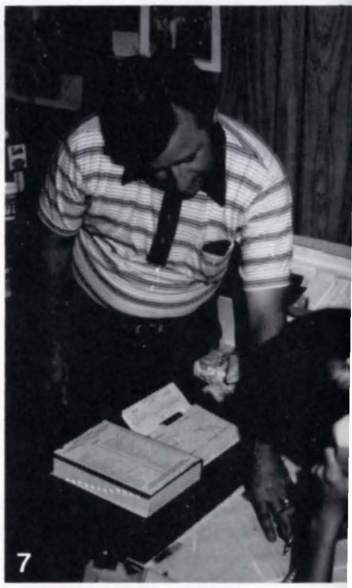
12. Carol Peterson coordinates the interviews and data received from the trained extension agents conducting interviews. Carol, from USU's Nutrition and Food Sciences Department, and Dave Vandervert, from the U of U's Dept. of Family and Community Medicine, organize the data and supervise its coding and verification. Carol also prepares the interview materials for the extension agents.

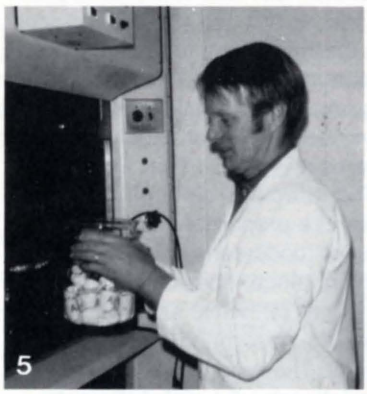
13. After collection, data are coded in preparation for analysis by computer. Virginia Howard, U of U's Dept. of Family and Community Medicine, is shown encoding such data.

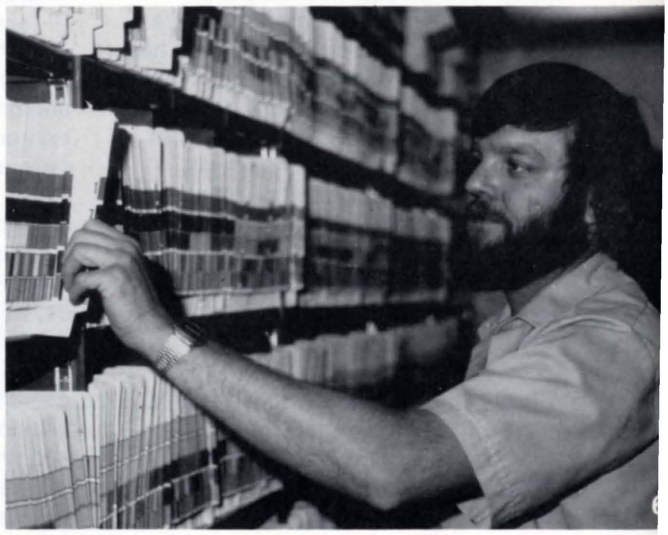
14. A monthly newsletter edited by David Vandervert allows the many investigators and assistants in the project to report their progress and keep abreast of the status of its other facets.

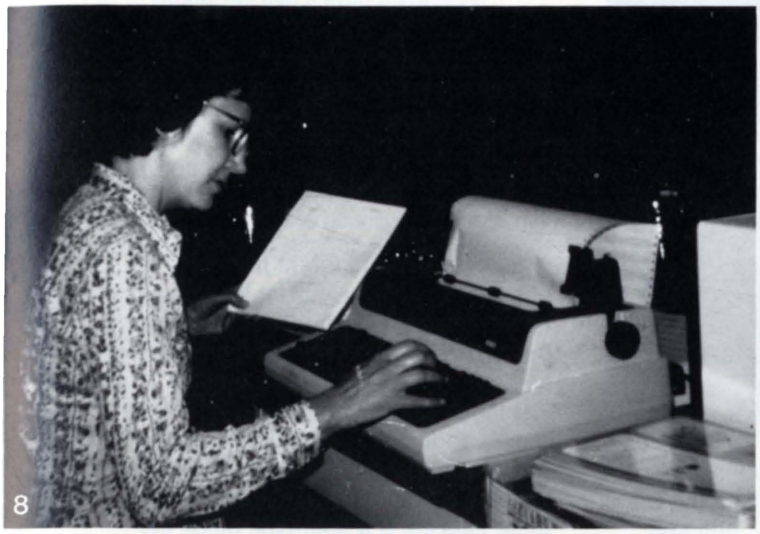
15. Don deBethizy, a predoctoral student in Toxicology at USU, is conducting his research thesis project as part of the study. Here he is in the animal lab where rats are being used to identify the pharmacologic effects of different types of diet fiber and how they influence the disposition of model drugs.







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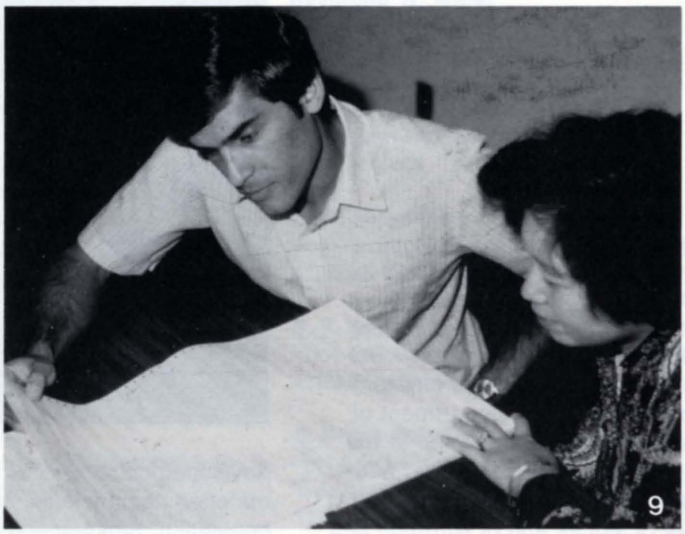
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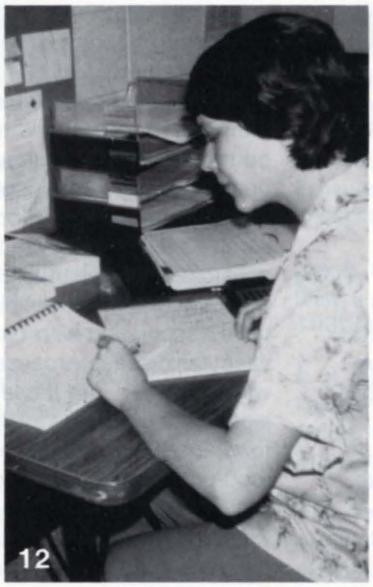
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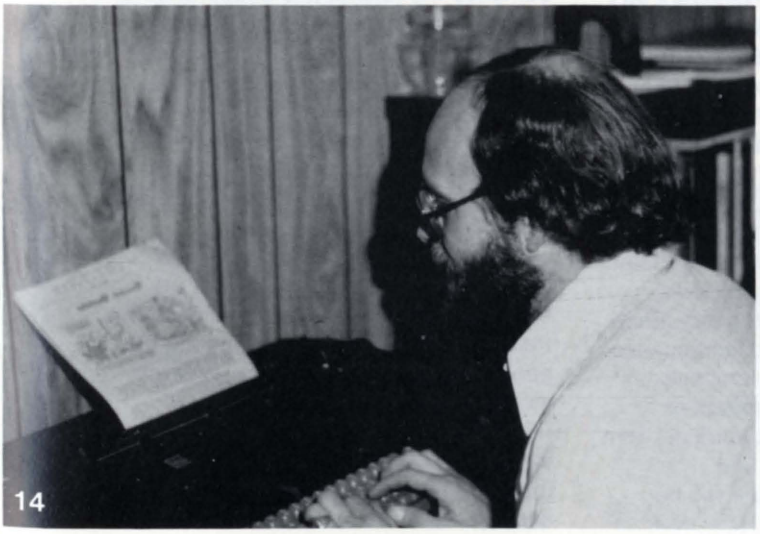
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Food Samples are freeze-dehydrated prior to analysis

What can account for this lack of agreement with theory? Finding the answer(s) is the purpose of a USU/U of U multidisciplinary research study. The program involves cooperative efforts among personnel in the Department of Family and Community Medicine at the University of Utah Medical Center and the Departments of Animal, Dairy, and Veterinary Sciences and of Nutrition and Food Sciences at Utah State University. Additional collaboration extends to the Wistar Institute in Philadelphia and several practicing Utah physician-surgeons. The entire study is supported by a grant from the National Cancer Institute.

Questions to be answered

The study addresses three major facets of the suspected link between dietary fiber and colon cancer: The first is the need to characterize the fibrous components of the major types of foods in our Utah diets. These are badly needed data, because dietary fiber includes substances such as cellulose, xyloglucan hemicellulose, pectins, gums, and lignins, yet existing analytical methods do not cover all of these. Today's "crude fiber" listings amount to only ill-defined, variable groupings of cellulose and some of the hemicellulose and lignin. One of the research group's working postulates concerning the Utah population is that their consumption of true total fiber is much greater than can be indicated by "crude fiber" data. New methods for chemically analyzing the types and amount of each fiber component are being developed for this project and will be applied to the known diet patterns of Utahns. The fiber and nutrient contents of home produced and/or processed foods will be compared to those of the same foods obtained from retail outlets.

The second facet requires carefully comparing the diets of Utahns who have developed colon cancer to those of matched healthy individuals in the Utah population. Simultaneously, fats and many other nutrients in the diets will be evaluated and compared. The 250 cancer patients and 500 healthy individuals will be interviewed to establish their dietary habits and to obtain data permitting adjustments according to gender, occupational, socio-economic, and cultural factors. Blood and stool samples will be analyzed for several physiological constituents such as cholesterol and other lipids thought to have association with cancer and vascular disease processes. The people will be divided into those who consume significant quantities of home preserved food and those who do not, and data on food preservation and storage methods will be considered. All the resultant data will be analyzed for possible correlations to cancer and other disease morbidity rates.

The third facet is the central question in the fiber/colon cancer theory. That is, what property(s) or function(s) of fiber in foods is (are) responsible for the effect. Answers to this question are being sought through a series of tests with laboratory animals (rats), using diets made with purified fiber components. Each of the special diets is being tested with a series of selected chemicals chosen as carcinogen surrogates. Each different chemical was chosen because its metabolism in the body emphasizes one of the major known aspects of carcinogen metabolism. Absorption from the intestine, metabolism, and elimination of each chemical will be evaluated.

By combining different fiber and chemical types, many hypotheses about the influences of "fiber" can be tested for the first time. For example, if a fiber type changes the growth of certain intestinal bacteria and thereby the time required for food passage through the system, this will be clearly indicated by the behavior of some of the chemicals to be studied. If a fiber-type binds the chemical tightly, thus interfering with its uptake, this too will be clearly indicated. These laboratory studies will help in generating a unifying theory about the specific effect of dietary fiber components as these occur in diets of different populations. With such a theory, the Utah case studies can be validly interpreted and new critical tests can be designed. For the first time, it may then be possible to understand the basis for the special colon cancer status of Utahns, of Utah Mormons vs Mormons living elsewhere, of California Seventh-Day Adventists and groups in other cultures where diet appears to be a major factor in their apparent resistance to cancer of the colon as well as to several other types of cancer.

This ongoing three-part study demands the talents and cooperation of a highly diversified research group (nutritionists, epidemiologists, medical sociologists, food chemists, toxicologists, biostatisicians, dieticians, home extension agents, computer specialists, and physician-surgeons). Figure 1 indicates how these specialists are now interacting.

Utah is fortunate in having both a uniquely favored population from the standpoint of its cancer morbidity, and a tradition of cooperativeness among its people, its scientists, and its research institutions. By taking advantage of these "givens," the USU/U of U study is expected to produce otherwise elusive insights into a major disease of modern society.

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